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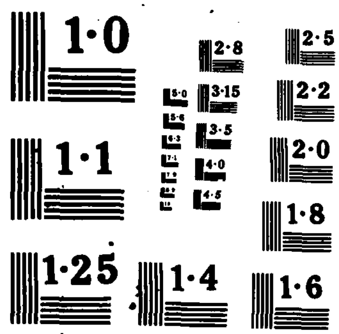

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DEVELOPING A STATISTICAL PROCESS CONTROL PROGRAM FOR NAVY SUPPLY OPERATIONS

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This report describes a cooperative effort between the Navy Personnel Research and Development Center and the Naval Supply Center at Oakland (NSCO) to develop a pilot project on quality control of supply operations using statistical process control (SPC). Although SPC is not novel, its application to a military supply center is unusual. An important feature of this research was the use of a technical evaluation procedure to determine variance points where SPC procedures should be applied. The report describes the first three phases of the pilot project: (1) the technical analysis of the supply functions to be controlled, (2) the procedures for data collection and analysis, and (3) some applications of SPC methods to supply operations.

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FOREWORD

This effort was conducted as part of the Management of Technological Change Project under the sponsorship of the Naval Supply Systems Command (NAVSUP) (SUP-069). The Navy Personnel Research and Development Center (NAVPERSRANDCEN) was assisting NAVSUP and the naval supply centers in the development and implementation of personnel management methods for the Naval Integrated Storage, Tracking and Retrieval System (NISTARS), a computer-directed warehousing system. Other Navy organizations should be able to adapt the methods to their own programs.

Two major objectives of the project concerned the analysis of organizational factors for NISTARS and the use of statistical process control (SPC) methods to monitor the system. The organizational analysis has been completed and is described in another NAVPERSRANDCEN report by Houston, Sheposh, and Shettel-Neuber (in preparation). This present report describes the technical analysis of the supply functions and the testing of the SPC method in a work center at Naval Supply Center, Oakland.

Appreciation is expressed for the high level of support and cooperation received from the Naval Supply Center, Oakland.

HOWARD S. ELDREDGE
Captain, U.S. Navy
Commanding Officer

JAMES W. TWEEDDALE
Technical Director

SUMMARY

Problem

An essential feature of effective implementation of new technology is a well-designed control system. Control systems are developed from an analysis of system requirements and a determination of the resources required to achieve the level of control that is desired. The Naval Supply Systems Command (NAVSUP) is implementing an integrated system for storage, inventory tracking, and retrieval that represents a major departure from the way these operations were performed in the past. The assistance of the Navy Personnel Research and Development Center (NAVPERSRANDCEN) was sought to assess the impact of this new technology on the organization and performance of the workforce.

Objective

The purpose of this report is to describe the method used to perform the technical analysis, the results of that analysis, and the potential for application of statistical process control (SPC) methods as a way to manage supply center operations.

Approach

A pilot project was conducted in one work center of the Naval Supply Center in Oakland, California. The method used for analysis was the sociotechnical evaluation procedure (STEP). This method results in a comprehensive analysis of the organization, but, for present purposes, only the analysis of the technical system is discussed here. The technical analysis identifies operations which require control in order to avoid adverse effects on quality, quantity, schedule, or cost. Such operations, referred to as variances, are typically controlled by personal intervention. For the purposes of the pilot project, some of these were examined using SPC methods to determine whether SPC could be used in lieu of direct intervention as a control system.

Results

The results of the ~~pilot~~ project support the practicality of using SPC methods to monitor and control supply operations. The STEP procedure was an effective method to obtain information about processes requiring control and to suggest measures useful for monitoring supply operations. When used in an iterative fashion, STEP was able to identify key variance points to be controlled by SPC methods. Supply center managers understood SPC methods when applied to supply center data. SPC methods gave information to the managers about their activity which they previously did not have.

Conclusions and Recommendations

1. SPC should be used to provide the naval supply center with quality control procedures needed to support NISTARS. Quality control problems that occur in the process can be measured. The supply center can use SPC techniques to monitor its own performance.

2. The Navy should investigate the feasibility of starting similar pilot programs at other Navy activities. Sociotechnical analysis and SPC are general, useful approaches to the analysis of an organization and the control of variation. Since the approaches were applicable at a supply center, they would likely work well at other industrial activities.

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INTRODUCTION

Problem

Dependable support by Navy supply centers for Navy ships and industrial activities requires constant attention to performance, productivity and the quality of output. At Navy supply centers this means getting the right material to the right place at the right time for the least cost. The Naval Integrated Storage, Tracking and Retrieval System (NISTARS), a computer-directed warehousing system, is being installed at Oakland, California, San Diego, California, and Norfolk, Virginia to meet this goal. Since NISTARS is a new system for supply operations, management control procedures had to be developed. In particular, the supply centers need performance data to make good decisions and meet mission requirements of quality and high productivity. To achieve these goals the authors have used statistical process control (SPC) methods to organize the data.

The management of Naval Supply Center, Oakland (NSCO) decided that a pilot project should be conducted that tests SPC in supply centers and demonstrates its application to Navy supply data. The pilot would also evaluate the utility of applying sociotechnical analysis to determine the key activities in a supply center that require management control.

Objective

This report describes a cooperative effort between the Navy Personnel Research and Development Center (NAVPERSRANDCEN) and NSCO to conduct a pilot project to test the quality control procedures needed to support NISTARS. Although SPC methods are not new, their application in a supply center setting is unusual. An important feature of this research was the use of a sociotechnical evaluation procedure (Davis, 1982; Taylor, 1975) to determine variance points where SPC procedures should be applied.

The report describes the first three phases of the pilot project: (1) the technical analysis of the supply functions to be controlled, (2) the procedures for data collection and analysis, and (3) some applications of SPC methods to supply operations.

Background

NAVPERSRANDCEN has conducted a sociotechnical system analysis of the physical distribution systems (including NISTARS) at the naval supply centers at Oakland and San Diego (Houston, Sheposh, & Shettel-Neuber, in preparation). This included a system scan, technical analysis and a social analysis. The present study at the Oakland work center concentrated on the system scan and technical analysis. The major work functions identified for the work center were similar to those uncovered in the earlier study.

The 544 Work Center

The primary responsibility of the 544 work center is to provide storage for repairable items. NSCO picked the 544 work center as the location of the pilot project for several reasons. The work center has relatively few employees and has a smaller amount of input and output and simpler operation than most of the other work centers. Finally, inventory accuracy was at the standard.

The 544 work center consists of three warehouses and a part of a fourth. Building 544 is the number of the main warehouse; the others are buildings 542, 543, and 444. The foreman, the offices, manual records and the phone terminal to a microcomputer are located in building 544. It is the central location of the work center and is also one of the two locations in the work center where material is received. In addition to the four warehouses, there is a large outdoor storage area chiefly containing drums of petroleum products and other very large items such as propellers. A small part of building 543 is the receiving area which takes in most of the items stowed at the 544 work center. The receiving function is performed by a contractor. Because it is not part of the 544 work center organizationally it was not part of the pilot project.

The 544 work center handles most of the repairable items at NSCO. These come from ships and other activities. The work center also handles new material from vendors, material ready for issue from activities ("A" condition), and repaired material. Repairable material ("F" condition) occupies most of the space. Most of the storage areas contain racks and provide space for bulk storage on the floor; a smaller area contains bin storage. Material stored in the 544 work center ranges from very large items packed in wooden crates to relatively small items stored on racks and in bins.

The warehouses are very large one-story buildings. In some sections lighting is poor although brighter lights are being installed. There are no conveyors or other mechanized equipment at the center. Most of the material is moved into and out of storage locations by forklifts.

The 544 work center employed nine people at the time of study, several of them on a temporary basis. They consisted of a foreman, a temporary leader, and seven warehousemen. One warehouseman is in charge of the outdoor area and most of the maintenance activities for the petroleum products. He usually has a crew who work chiefly on the material stored outdoors. Other warehousemen are assigned to specific buildings and perform both stowing and issuing functions. Occasionally warehousemen will be borrowed from other work centers. There is also a weekend shift.

In addition to the leader, foreman and the seven warehousemen, other NSCO and contractor employees work part-time in the 544 work center. These individuals include: a quality control inspector, members of the operations analysis team who straighten out inventory and improve the physical condition of the work center, and contractor personnel who conduct inventories and follow-up on material that cannot be located.

Physically, the 544 work center is not very different from other large bulk warehouse centers at NSCO. It is unique, however, in the amount of repairable items it stores and in the wide variety and number of line items it handles.

APPROACH

Sociotechnical Analysis

The sociotechnical systems evaluation procedure (STEP) is a method of describing and analyzing organizational process. STEP takes into account the relationships among technology, people, tasks, structure and goals to produce an organizational design that optimizes the technical and social systems to achieve the organization's mission. The technical system concerns the ways inputs to the organization are transformed into outputs (goods or services); the social system concerns the people required to operate the

technical systems and maintain the organization. The results of STEP analysis can be used to identify needs for change in structure, management practices or work processes. Thus, the method provides a basis for design or redesign of the organization (Cherns, 1976; Taylor, 1975). Usually, three analyses are done prior to the design stage.

System Scan

The system scan defines the organization's overall mission, boundaries, inputs, outputs, important environmental elements (elements outside its boundaries), economic objectives, social objectives and major problems. The mission is the purpose toward which the organization strives. (It may not have been clearly defined before.) The organization exists to transform inputs into outputs. An organization has boundaries around it that are specific. These include the points where inputs enter and outputs leave the system. The boundaries can be described in terms of physical limits as well as in terms of time and personnel. Environmental elements influencing the system include physical constraints, as well as political, regulatory and social factors. Finally, the system scan identifies problems that the organization faces.

Technical Analysis

The technical analysis describes the flow of operations and the procedures used to transform inputs into outputs. The transformation process is broken down into activities called unit operations. Each unit operation has its own inputs from within or outside the system. Some inputs are throughputs, that is, they are not changed by the process. The outputs may be inputs to the next unit operation or the final output from the system.

A crucial feature of the technical analysis is the identification of variances within and between unit operations. Variances are points in the process where an absence of control could affect quantity, quality, cost and time. To maintain an effective and efficient process, these points must be brought under control. Key variances are those with the greatest impact on the outputs.

Social Analysis

The social analysis determines the communication requirements for optimal performance by the people and the technical system to support the mission. This pilot project did not include a social analysis.

Statistical Process Control (SPC)

W. A. Shewhart (1980) developed the concept of SPC. The central theme is that every product or service results from a process that contains inherent variability. Usually inspectors compare the final output with a standard (design or engineering specifications) and the item is accepted or rejected based on the comparison. Shewhart showed that by reducing the variability of the process the output becomes more uniform. Greater uniformity ultimately leads to better quality. He found that much of the variability came from "over-control" which occurred when the process was changed any time an item failed to meet the standard. Shewhart used probability theory and the statistics of dispersion to develop control limits to determine when changing the process is justified. The limits are marked on charts that display the variability in the process. Whenever the process is out of control (when performance goes beyond certain probability limits) the causes are

analyzed and local changes are made to bring it back into statistical control. Although Shewhart developed the concept for manufacturing systems, they apply as well to other systems such as administrative or repair.

Several techniques are available for monitoring the process and solving problems associated with it. Ishikawa (1982) and Grant and Leavenworth (1980) describe the most important ones. Flow charts give a breakdown of the parts of a process. Histograms show the distribution of a variable. Ishikawa diagrams describe cause and effect relationships between a goal and the steps to produce the goal and are also used to identify causes of problems. Pareto diagrams give the relative importance of possible causes. Run charts show time trends. Control charts monitor the uniformity of output. Scatter diagrams demonstrate correlations. Typically, a process is monitored at strategic points using control charts and run charts, as was done in this study. When a problem occurs the other techniques can be used to help identify its causes.

Deming (1982) took Shewhart's ideas one step further and developed a management philosophy for organizations that use them. He and others contend that only 15 percent of the problems of quality come from parts of the process that can be controlled by the worker; the remaining 85 percent come from the system components under control of management (Juran, 1974). According to them, a worker works within the system but cannot change it--only managers can do that. Deming emphasized that once a process is under statistical control, only management can change the system if quality is to be further improved.

Wheeler (1983) explains Deming's ideas by saying that each process falls into one of four possible categories of stability and performance. The ideal state is where the process is under statistical control and the product conforms to the desired result (i.e., conforms to specifications). The threshold state occurs when the process is under statistical control, but some product does not conform. Brink of chaos occurs when the process is out of statistical control but the product conforms to the desired result. Chaos results when the process is out of statistical control and the product is nonconforming. If the process is out of statistical control, the first step is to bring it into control; this is largely a local problem for the workers to deal with. Getting a uniform output from the controlled process does not ensure a desired output if the output does not conform to specifications. A desired output is the result of the system organization and, as Deming argues, only the managers can change the system.

A Comparison of Sociotechnical Analysis and SPC

This research seeks to apply SPC methods in two new ways: To control key variances and to organize supply center data. The use of both SPC and sociotechnical analysis requires an explanation of how their structures match.

The relationship of the technical analysis to SPC is straightforward (Dockstader, 1984; Houston et al., in preparation). Usually SPC begins with a flow chart of the process. The phrase "unit operations" is not used but the result is the same. Next, SPC is designed to look at problems that can occur and to determine the possible causes. One of the principal tools to do this is the Ishikawa diagram which shows the factors that influence a result. This diagram is analogous to a variance matrix. Several factors are chosen for detailed analysis and data-gathering. Pareto analyses are used to rank the factors in importance based on their impact on the outcome. The selection of factors and their ranking are similar to the choices concerning key variances in a technical analysis.

One of the differences between sociotechnical analysis (STEP) and these SPC methods is that SPC is more numerically-oriented. In addition, STEP looks for the

interdependencies among operations, while SPC deals with specific problems. Consequently, STEP analysis usually considers variances that SPC ignores. STEP analysis has not in the past attached numerical values to the variances; in fact, some variances may not be numerically measurable. However, for those that are, SPC provides the tools to analyze and control them.

With respect to approach, STEP analysis is intended to analyze the structure of an organization in terms of its mission. The analysis is intensive and inclusive; all factors affecting the mission are considered. SPC begins with a problem statement (e.g., the need to improve inventory accuracy in a warehouse) and then determines factors that impact the problem. The problem may be with the organization's output, the entire process by which the output is produced or with specific parts of the process. In such cases, SPC methods such as control charts may be used to control each step of the process. In other cases, SPC methods may be used only to analyze a particular problem without regard to the entire process. In the former case, SPC is similar to STEP analysis in scope but uses numerical data. In the latter case, SPC considers only a limited aspect of the organization's activities.

Site Visits

NAVPERSRANDCEN personnel made six visits to NSCO to conduct the pilot project. The first was an orientation to the 544 work center. A sociotechnical analysis began with the second visit and continued for the other visits. This analysis identified the variances and key variances. Interviews were conducted with the foreman, leader and several warehousemen. Continual observations and discussions of material movement, paperwork and problems provided information needed to obtain a complete understanding of the technical system. In addition, interviews were conducted with other NSCO functional units which affect the 544 work center.

By the fifth visit, data sources for the variances were identified. Data collection began and SPC charts made. On the sixth visit, additional data collection began for variances not covered by existing NSCO data collection procedures. At this time managers were briefed regarding SPC charts and asked to comment.

RESULTS AND DISCUSSION

Sociotechnical Analysis of the 544 Work Center

System Scan

For the 544 work center, which is a small component within NSCO, the following parameters were defined:

Mission. Stow and issue the proper material within the time frames allowed; maintain inventory accuracy at the Naval Supply Systems Command (NAVSUP) standard or above.

System Output. The correct material in the correct quantity with the correct document placed on some form of transportation and sent to packing or, in relatively rare instances, sent directly to the requester.

System Input. Material arriving from receiving (or directly from a vendor for drums of petroleum products); requests from customers (issue documents).

Input Boundaries. Areas in buildings 544 and 444 where material arrives from receiving; outside storage areas where drums are received; arrival of issue requests at building 544.

Output Boundaries. Loading areas where the issued material is placed on transportation to be sent to the next unit operation (usually packing) or given directly to the customer.

Physical Boundaries. Buildings 544, 542, 444, and that part of 543 not occupied by the receiving process and associated outside storage areas.

Time Boundaries. Standards within which material from receiving must be stowed and within which material must be issued. The stow time is seven work days from time material arrives at receiving (outside the 544 work center boundaries) to the date the material movement document (MMD) is sent to receipt control. The issue time varies with the priority indicated on the issue document and is calculated from the date on the issue document to the date the material is shipped from NSCO (proof of shipping). It should be noted that the time boundaries are not explicitly defined for the 544 work center itself. The boundaries involve unit operations within NSCO but outside of 544.

People Boundaries. The nine individuals working in the 544 work center and the management and staff (general foreman, commander, assistant director of bulk distribution, supply analyst). Individuals outside the organizational boundary of the 544 work center (inventory control, inventory audit, quality control, operational analysis, etc.) also work within the physical boundaries of the 544 work center and may influence operations.

Environmental Elements. Workload (stows, maintenance activities and issues); repair of forklifts; ability to obtain extra workers when needed; problems with material coming from the receiving operation (wrong stock number, quantity, condition code); characteristics of workers hired and sent to work in the 544 work center; changes in procedures affecting handling material; and the installation of a phone terminal to input data about material stowed.

Presenting Problems. Maintaining inventory accuracy within NAVSUP standards; issuing of large numbers of items for disposal; locating material purportedly sent from the Mare Island repair facility to the 544 work center; and maintaining accuracy of the central computer file (master stock item record or MSIR) for the material stowed in the work center.

The system scan defined the organization in a way that all could understand and within a context that supported a technical analysis.

Technical Analysis of Unit Operations

A unit operation is a set of activities that transform inputs into outputs. The inputs come from either outside the system or from another unit operation within the system. The outputs either go to another unit operation or leave the system. In the 544 work center three major unit operations were identified--stowing, maintenance, and issuing. A fourth unit operation, direct receiving, concerns material received and stored outdoors (e.g., drums of petroleum products).

Figures 1, 2, and 3 present flow charts of the three major unit operations. The processes indicated in the large box are those carried out within the unit operation. Those processes outside the large box are either the inputs to that unit operation or the outputs. The outputs of each unit operation can become inputs to another unit operation but not necessarily of the 544 work center. In these figures, parallelograms within the large box indicate inputs which are initiated within the unit operation or outputs which do not go beyond the unit operation. It should be noted that each process represented within the unit operations can be further analyzed into its component activities.

Stowing. Figure 1 represents the stowing operations. The stowing operation involves receipt of the material from the outside. This is accomplished by the actual movement of the material into the center and updating the computer files or MSIR. The inputs are the material and information about the material. The outputs are the material in storage in the work center and an updated computer file indicating the location, stock number, quantity, and condition code, as well as other information about the material. Greater detail about the stow operation and Figure 1 is presented in Appendix A.

Maintenance. The next unit operation, maintenance, takes place after the material has been stowed. The maintenance activities affect only a small proportion of the items, those with a shelf-life or those requiring changes in stock number or other information. Inputs to the maintenance operation come from outside NSCO, from within NSCO and from changes in the material itself because of the expiration of the shelf-life. Outputs include sending the updated information to storage control, where changes are made to the MSIR and to the condition code and stock number on the material. Appendix A provides more detail on the maintenance operation and explains the flow represented in Figure 2.

Issuing. The issuing operation is the final step in the transformation of the material in the 544 work center. This unit operation involves taking the material from storage and preparing it for the next operation (usually packing) before it is sent to the customer. The input is an issue document which originates outside NSCO requesting material for a customer. The documents accompany the material. The output consists of the material and documents that are sent out of the work center. Appendix A presents more detailed information about the issuing operation and Figure 3.

Variances

One of the most important results of a sociotechnical systems analysis is the identification of variances. A variance is a deviation or variation from a norm, standard, or specification that affects quality, quantity, cost or time. Variances arise from characteristics of the input, from the process of transforming input to output, or from the equipment used in the process.

The authors conducted interviews with the foreman, leader, and several workers. The leader is an assistant to the foreman. Major tasks appear to involve troubleshooting and dealing with perturbations (variances) in the system. In addition, we observed the various activities of the center (e.g., issuing, stowing, and maintenance changes). Flow charts of the basic process and lists of variances were developed and checked with the foreman several times. Each visit produced more information about variances as we observed the problems brought to the leader and foreman and the actions they took to solve them. In questioning the foreman and leader about the variances we sought their opinions on frequency of occurrence and the importance of the problems in terms of the effort to resolve them and their possible effect on the process and output.

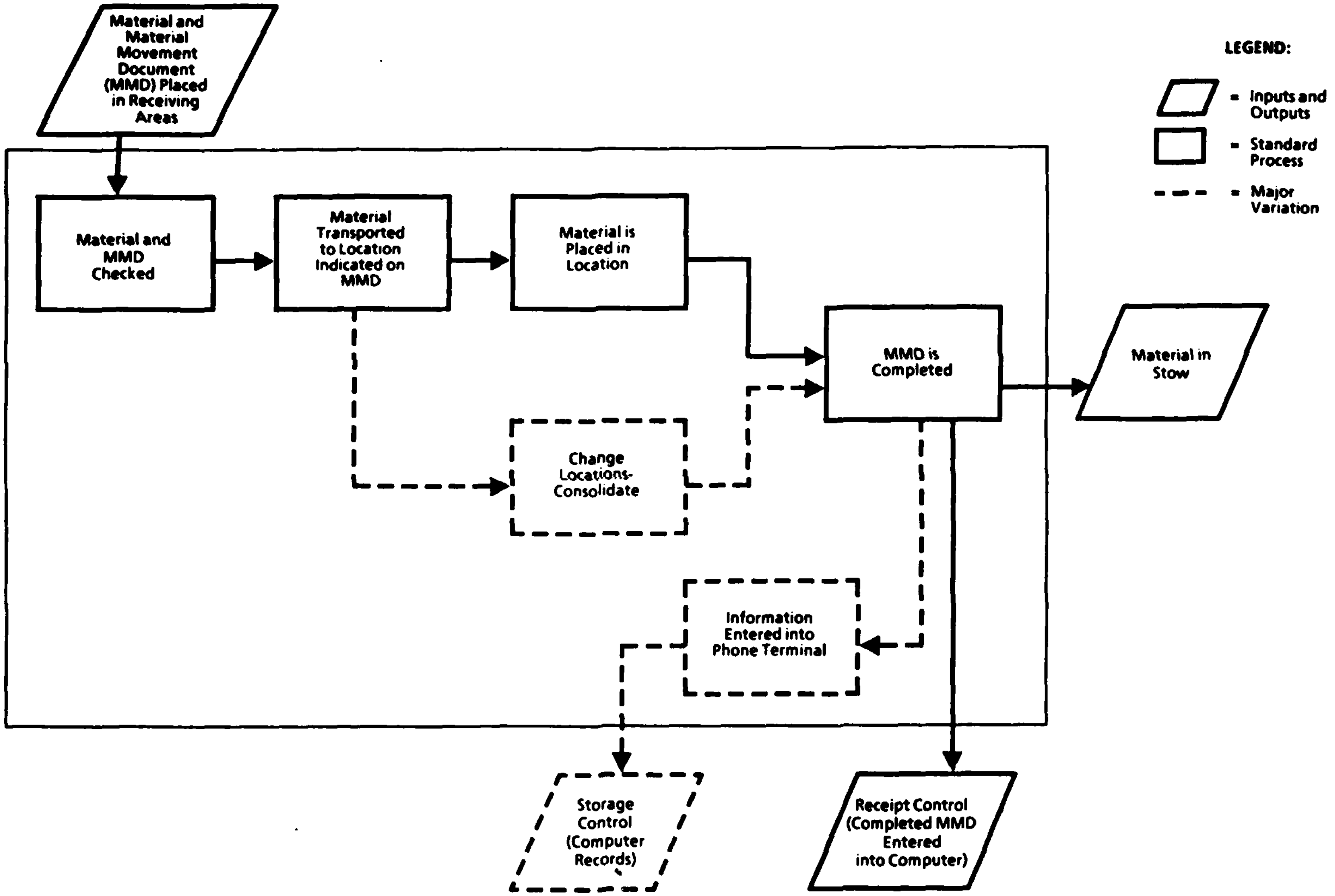

Figure 1. Flow chart showing the stowing of material received by the 544 work center.

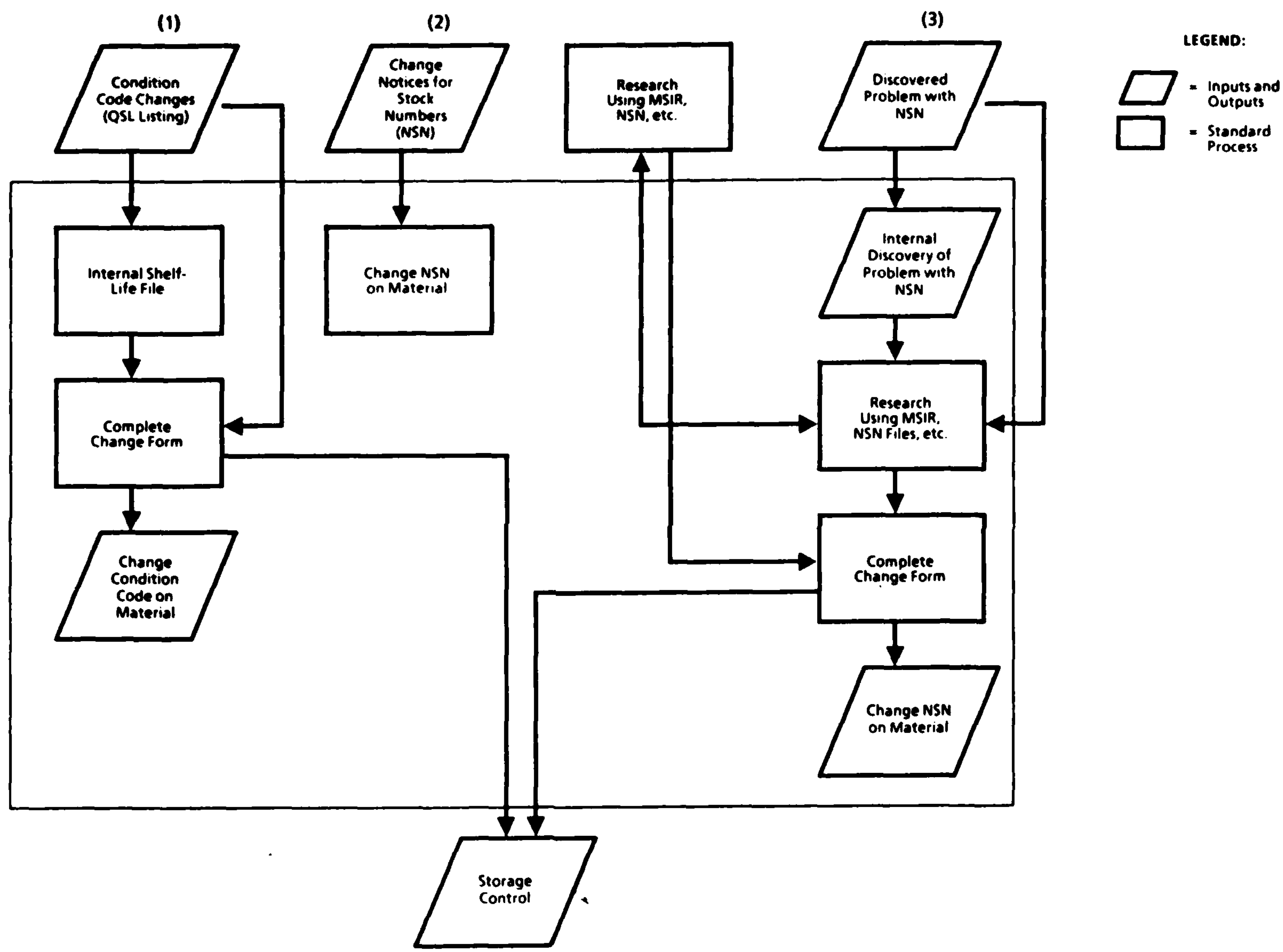

Figure 2. Flow chart showing maintenance activities required for items stowed by the 544 work center.

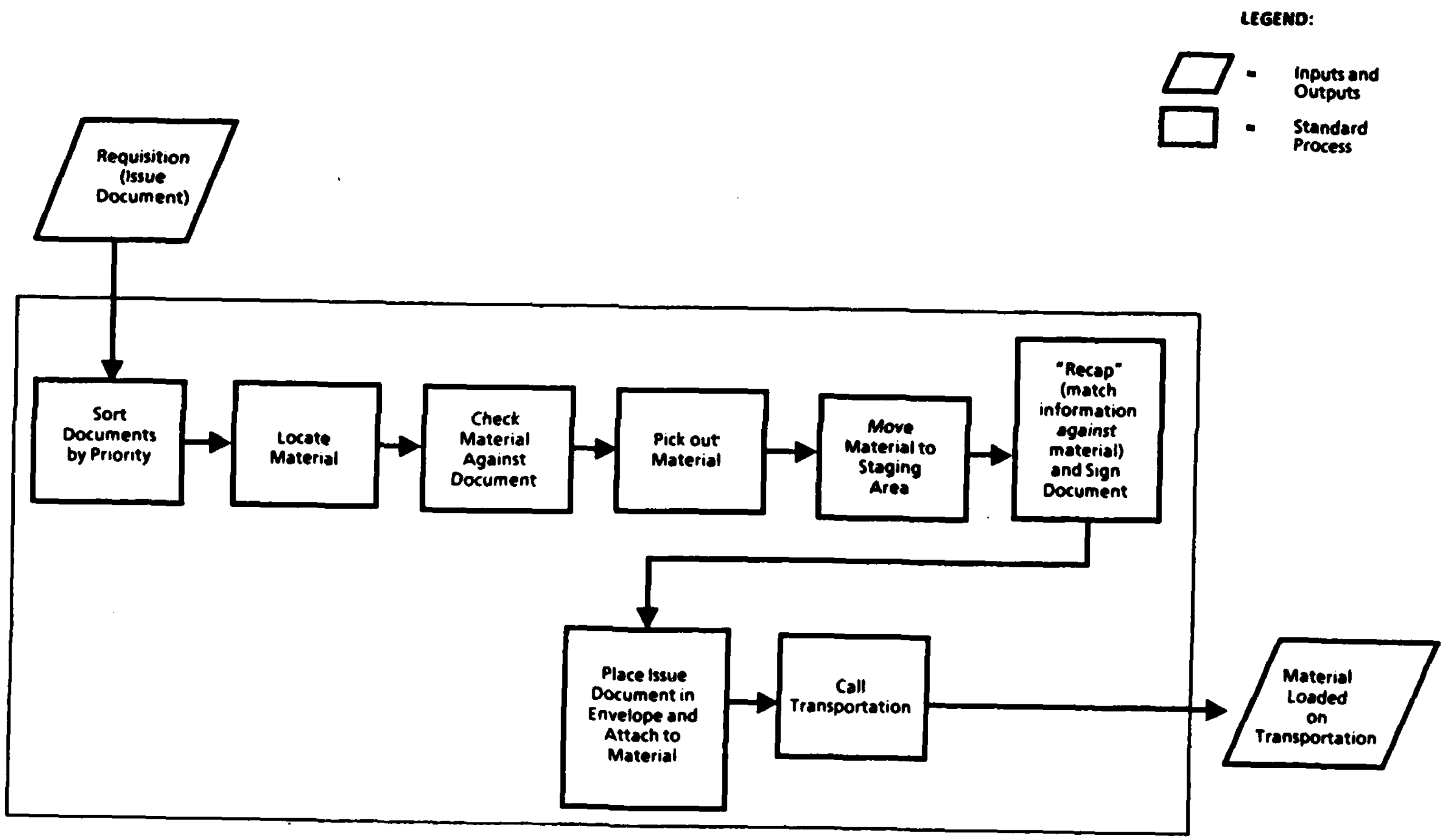

Figure 3. Flow chart showing the issuing operation of the 544 work center.

Variances were categorized in terms of unit operation. Although the flow diagrams of the unit operations (Figures 1, 2, and 3) were relatively simple and straightforward, the nonroutine actions were numerous and, at times, complex.

A variance matrix, as described by Cotter (1983), was developed for the 544 work center. Figure 4 shows this matrix with the variances grouped by unit operations. Dots in the intersections of two variances indicate that the preceding one influences the following one. The interrelationships are hypothesized--they are not based on empirical data but rather on logic and knowledge of the process. The matrix does not take into account frequency of occurrence. Thus, some variances are shown to affect or be affected by many other variances, but their occurrence may be infrequent. Some variances occur within each unit operation, for example, variations in volume of input.

The causes of some variances listed in Figure 4 originate outside the 544 work center. Although control of them is outside the work center's power, there may be ways to handle some of them so as to mitigate any effects on the rest of the process and on the output. For example, volume fluctuations for stowing, maintenance, and issuing are chiefly a function of systems outside NSCO. Variances 4-9 in the stowing operation are inherited from the receiving operation. Some of them may have originated with the party who shipped the material to NSCO and will influence the issuing operation as well (variances 33 and 34). Other variances originating outside 544 include 22 and 40.

As mentioned earlier, some variances are internal. Examples are variances 12-15 in the stow operation, variances 21, 23, and 24 in the maintenance operation, and 35-38 for issuing. Still other variances may be considered a function of the interaction between the processes in the work center and other NSCO unit operations. Examples are variances 16 and 17. "Worker training/motivation" (variance 31) is another important variance. Since the work center involves a labor intensive process, there is a strong possibility of a relationship between training/motivation and other variances.

Forty-two variances were identified. Appendix B lists each of the variances, gives a brief definition of each, defines the data needed for measurement, and lists the source of data.

Several steps must be taken to use knowledge of variances to advantage:

1. Measurement of the variance, that is, frequency of occurrence, variability, and other characteristics using the various SPC methods.

2. Determination of relationship of the variance to other variances as well as to inputs, outputs, and measures of quality.

3. Determination of the possible causes of the variance.

4. Identification of the locus of cause within or outside of the 544 work center.

5. Initiation of plans for testing possible solutions to control the variance.

The first two steps can be used to identify key variances. Other variances may be designated as key variances due to the fact they are variances to other unit operations, for example, variance 19.

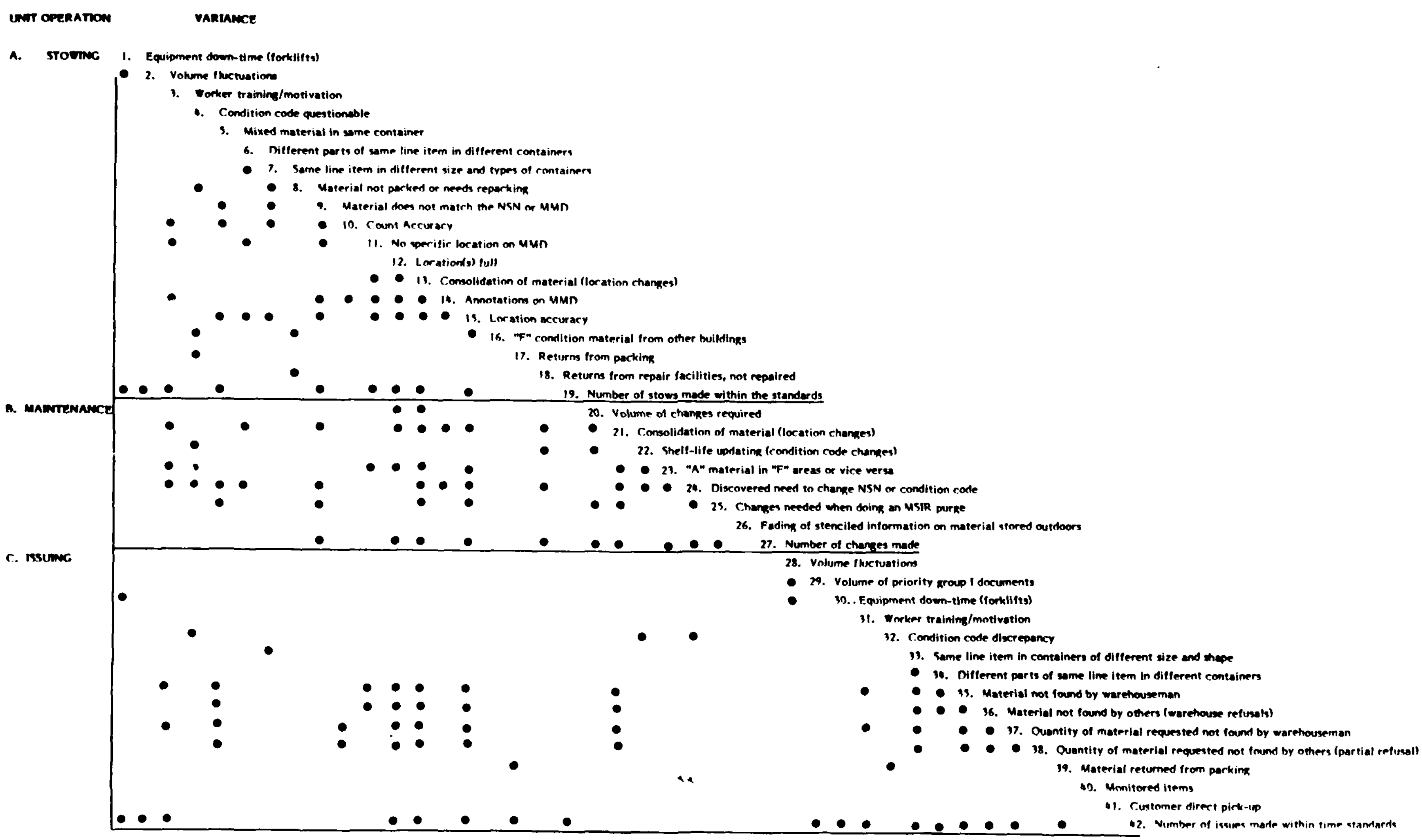

Figure 4. A variance matrix showing the relationships between variances that can occur during stowing, maintenance, and issuing operations.

Key Variances

Key variances are those with the greatest impact on the throughputs and outputs of the organization in terms of quantity, quality, cost, and time. They are the problem areas that require greater control to improve quality and raise productivity. Changes in the system to control key variances should lead to improvement in productivity and quality.

Greater control of key variances will produce measurable and significant effects. Control can take the form of reducing the effect of the variance, decreasing its frequency of occurrence, or developing more efficient and effective ways of dealing with it. A list of key variances as perceived by the researchers and the foreman of the 544 work center is shown in Table 1. Criteria used by the foreman included (1) frequency of occurrence, (2) time needed to deal with the variance, (3) potential effects on meeting inventory standards, and (4) time needed to stow and issue the material.

Data for some of the key variances were available from routine records. These data as well as other important daily work activities are recorded by the 544 work center foreman on a daily backlog and situation report (see Appendix C). Each warehouse worker submits a daily breakdown on the number of hours spent in each of several activities (stowing, issuing, maintenance, training, etc.) as well as the number of line items stowed, issued, subjected to maintenance activity, etc. Also reported on the form are: stow and issue backlogs, warehouse refusals, partial warehouse refusals, number of trucks loaded for drums of petroleum products, number of issue documents in each of the three major priority group categories, and other activities. The reports are submitted to the general foreman who, in turn, transmits the report to the director of bulk distribution.

NAVPERSRANDCEN developed procedures that allowed the 544 work center staff to count the frequency of key variances not currently recorded as well as to keep track of several variances not included in the key variance list. A form was prepared for use by the foreman and leader of the 544 work center (see Appendix D).

The leader's workload and, to a lesser extent, the foreman's consisted of dealing with the variances. Problems were brought to their attention by warehousemen, auditors, and inspectors and from other NSCO activities such as the requirements division. The activities involved in variance control ranged from physical search for material to perusal of microfiche lists of stock numbers cross-referenced against parts numbers.

SPC Applications

The authors used three tools to perform the technical analysis. The first step was the design of flow charts of the unit operations (Figures 1-3). Next, a variance matrix was developed that showed where variability can occur and where one step of the process can influence later steps (Figure 4). Since the matrix was constructed to show the steps of the transformation from inputs to outputs, it showed the same steps displayed on the flow charts. Third, the key variances were selected from the variance matrix.

In implementing SPC at the NSCO, two studies were completed. First, problems affecting quality control were identified through interviews done for the sociotechnical analysis. They are identical to the "presenting problems" of STEP concerning inventory control. Second the numerical techniques of SPC were applied to work center data to display variability in workload, productivity, and warehouse refusals at NSCO over time. Charts and data were presented to NSCO managers to find out if they understood the concepts and could interpret the charts. The ideas and results were clear to them when their own data were used.

Table 1

Key Variances in the Unit Operations of the 544 Work Center

Stowing	
1.[a]	Equipment down-time (forklifts).
2.	Volume fluctuations (number of items to be stowed).
12.	Location full: No room to stow material at locations indicated on MMD.
13.	Consolidation of material (location changed from that on MMD and from location in which material is presently stowed).
15.	Location accuracy (accuracy of location in which item is stowed against location listed on MMD).
17.	Returns from packing: Material issued and sent to packing is returned, often due to missing or replaced documents; the returned material must be restowed or reissued.
19.	Number of stows made within time standards (output).
Maintenance	
20.	Volume of changes required.
24.	Discovered need to change NSN or condition code: Through inspection, audits, or 544 staff work, material already in stow is discovered to have questionable NSN or condition code.
Issuing	
28.	Volume fluctuations (number of items to be issued including material to be sent for disposal).
29.	Volume of priority group I documents - number of priority group I issues to be made.
30.	Equipment down-time (forklifts).
35.	Material not found by warehouseman.
36.	Material not found by others (foreman, leader, quality control inspector).
37.	Quantity of material requested not found by warehouseman.
38.	Quantity of material requested not found by others (foreman, leader, quality control inspector).

[a]Numbers refer to variances identified in Figure 4 and Appendix B.

Problems Affecting Quality Control

The supply center is concerned about accuracy in four areas: location, material, count, and MSIR accuracy. Two important performance areas that are closely related were also analyzed: delays in stows and issues and productivity. These concerns are addressed below. Most of these problems are conceptualized as variances (see Appendix B, variances 9, 10, 15, 19, and 42). Also, other variances identified and listed in Appendix B have logical relationships to these problems since one variance may affect other variances occurring later in the process. For example, location accuracy (discussed below and listed as variance 15) can be influenced by: no specific location listed on the MMD (variance 11), consolidation of material (variance 13), and annotations on the MMD (variance 14). All these may contribute to material not being stowed in the proper location and/or inaccuracy in recording where the material is stowed.

Location Accuracy. This is determined by a physical audit of the warehouse. The stock number, quantity, and location of each line item on the MSIR data base are checked against the containers in the warehouse. The stock number and quantity are external numbers found on the container; the container is usually not opened to verify them. NSCO regarded location accuracy as its major quality problem.

Material Accuracy. This information is found by comparing the contents of a container with the stock number on the container and on the document accompanying the material. Present NAVSUP policy is to not routinely open containers to verify that the actual material corresponds to the information on the container and on the document. This policy may be reasonable for items from commercial vendors where the contents are regular and specified by contract but can lead to problems for material coming from ships or other Navy activities where the contents are usually one-of-a-kind and more likely to be mislabeled. Since much of the material received at the 544 work center comes from the Fleet, warehouse personnel are encouraged to question material accuracy whenever something appears irregular, that is, the same stock number may be on containers of different size and shape.

However, since containers are not routinely opened to inspect the material, the stock number on the container or the document may not reflect what is actually in the container. As a consequence, material stowed and later issued may not be what the customer ordered.

Count Accuracy. Discrepancies may occur between the actual quantity of a line item and the quantity listed on the document and on the container and thus recorded on the MSIR. This discrepancy could result in a partial issue if the quantity of the item requested exceeds the number actually available.

MSIR Data Accuracy. This area becomes a problem because warehousing consists of both material and paper flow. The paper flow requires the warehouseman to write a 13-digit stock number and a 10-digit location number for every change in location for an item. These numbers must also be entered into the computer to update the records. Errors may occur when the warehouseman writes the numbers, when the foreman transmits them to storage control, and when storage control personnel enter the data into the computer. Other data entry errors may also occur on routine recording of stock numbers, quantity, and location; but these do not usually involve errors on the part of 544 personnel.

Delays. These occur when stows and issues are not processed according to NAVSUP standards. Stows have to be made and recorded on the MSIR within seven days of arrival at the supply center. Issues have different priorities in terms of the time between arrival

of the request and the time the material must leave the supply center. Another problem may occur upon an issue delay. If material is not issued, shipped and recorded on time, other requests for the same line item may arrive before the material is subtracted from the MSIR. This creates a situation in which the supply center may not be able to issue the amount of the material requested by the second party since it is already being issued but has not been subtracted from the stock on hand.

Productivity. This area involves the processing of stows and issues within NAVSUP time standards as well as the completing of maintenance activities needed to keep the material and the records updated with respect to condition, stock number changes, etc. The number of inputs (i.e., the number of stows, issues and maintenance tasks) will vary. Excess backlog is an indication of productivity problems.

In general, most problems of quality are blamed on warehousemen. However, through the technical analysis we discussed difficulties that often involve other parts of the NSCO. Although the boundaries in the pilot project were drawn along organizational lines, future analysis of quality problems should include other parts of NSCO.

Numerical Techniques

After the sociotechnical analysis was completed and the areas of quality control were identified, data gathering and analysis began. Three examples from the 544 work center show how SPC concepts and techniques can be applied at NSCO. SPC assumes that every process contains variability. In the past, managers looked at data for a day at a time. Through the use of SPC run charts they are able to monitor the workload over an extended period and can see the way backlog is influenced by variations.

Workload Variability Using Run Charts. Figure 5 is a run chart of daily input, output and backlog for issues in the 544 work center between January and March 1984. The number of daily issues to be processed varied from 4 to 271, the number actually processed varied from 12 to 203, and backlog varied from 0 to 88 line items. Average issue backlog was 12.9 line items. Figure 6 gives the same type of data for stows. Figure 6 shows that stows are handled differently than issues. Stow backlog is seldom worked off. The number of stows exceed the number of issues by almost half. Stows and issues are more in balance in other warehouses at NSCO.

At NSCO issues have highest priority, followed by stows and then maintenance activities. "Disposals" (sending material to be disposed of) are supposed to rank with issues but in practice do not. Personnel are assigned to a work center based on the average number of issues to be processed per day. The daily work schedule is set by the foreman. He handles the problem of variability in stows and issues and maintenance activities by shifting people among the major tasks. By comparing the run charts on workload with control charts on productivity (shown later), the foreman and the director of bulk distribution can assign warehousemen to different tasks to manage the backlog.

Productivity Using Run and Control Charts. Productivity at the supply center is measured by the number of issues or stows accomplished per man-hour. An issue or stow is a line item. The data for this appear on the daily situation report which gives the number of line items worked and the time required to work them. Line items may range in size and volume from one small box to 4 or 5 large cartons to hundreds of drums of petroleum products. Also, a warehouseman is assigned to tasks in half-day increments; what he completes in that half-day might vary depending on the volume. In one increment he may complete 23 issues, but in another increment only 12. Typically, managers only look at output for one day and judge performance based on that. Their decisions do not take into account how variability within one day's workload impacts the next day's work.

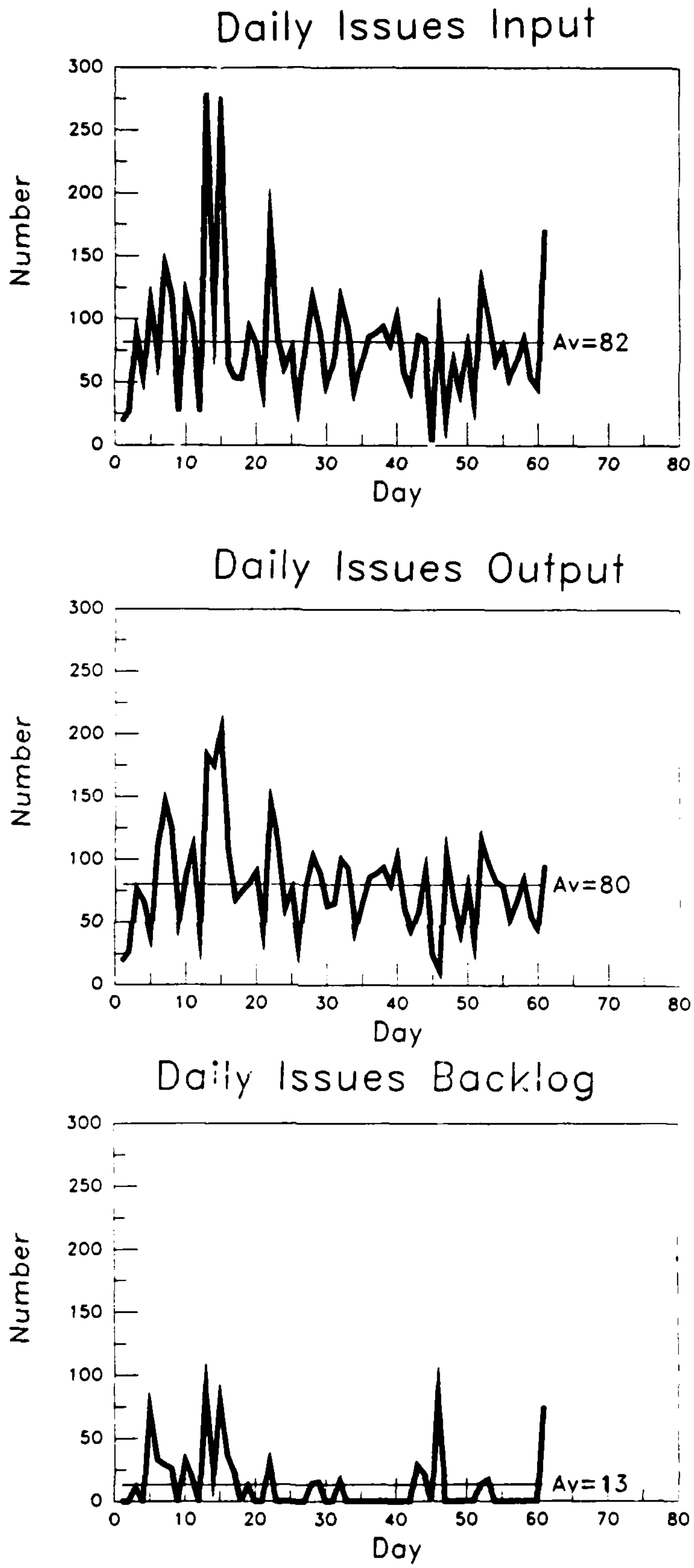

Figure 5. Run chart displaying workload variability and backlog pertaining to issuing activities.

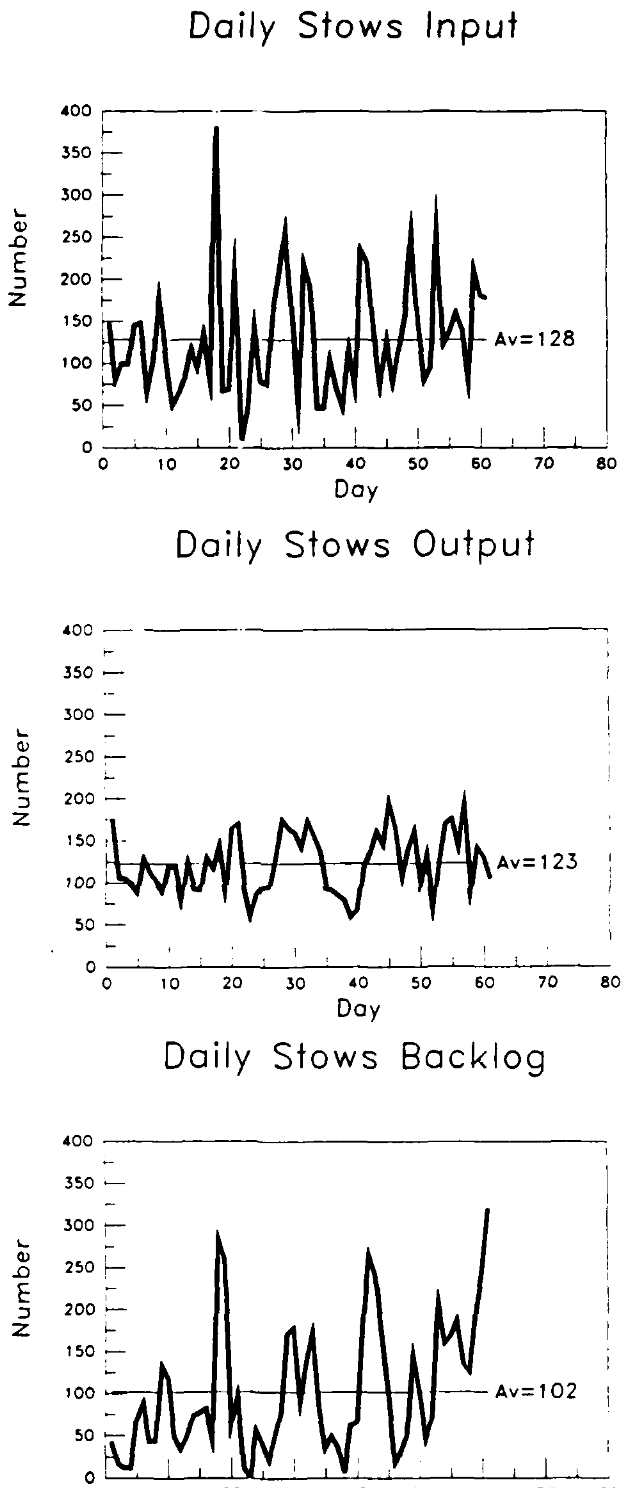

Figure 6. Run chart displaying workload variability and backlog pertaining to stows.

The variability of productivity is shown by Figure 7, a run chart for the daily productivity issues. The run chart shows no particular trends; productivity is steady. The supply center's standard for productivity is 4.0 issues per man-hour; on average, warehousemen were working 15 percent above standard.

Figure 8 shows the mean and range control charts on productivity. A control chart uses the statistical properties of samples to set upper and lower control limits (UCL and LCL) that indicate when something unusual is happening in a process. Assume a measure of a process, such as productivity, is random with an unknown mean and variation. From that process take a random sample of values. The statistic for the average of the values will then have a normal distribution with a mean and variance that can be estimated from the samples. A control chart of the means over time consists of a plot of the sample mean values along with control limits that are three standard deviations on either side of the central line which is the estimated mean of the sample means. A range chart shows the dispersion of values within each sample and control limits around its mean. The workers can take action to fix a process when the control limits on the mean or range charts are exceeded. (Typically, a cause is found for a problem and is corrected.) In Figure 8 the sample for the control charts is a five-day week. Control lines are based on five points per sample. Unfortunately, for four weeks only four points were available due to holidays and missing values. In these cases the sample mean was based on four points, but the control lines were drawn on the assumption of five points per sample. From Figure 8 we see that the productivity affecting issues is in "statistical control" with no significant trends. The fact that average performance is above standard (4.0 issues per man-hour) is even more clear on the control charts.

Figures 9 and 10 show the productivity data for stows. Issues are more important to the goal of the supply center than stows, but accurate stowing is necessary for accurate issuing. The control charts (Figure 10) show two out-of-control points. The reasons for them were not determined since the data were historical.

The managers at the supply center were able to understand the run charts on workload and backlog; they were also able to understand the run charts and control charts on productivity. They saw the potential to reduce backlog by using the productivity data for making trade-offs between warehouse staffing and average backlog for issues and stows. They appreciated the importance of bringing productivity data under statistical control and of its use as a planning tool. They also understood that improvements in productivity require system changes.

Because the supply center relies on performance standards, the managers needed an explanation of how SPC methods (especially the control chart) relate to them. The authors explained that standards or specifications for a process may fall within or outside of the "natural" variability or capability. If points in the process are outside of the standards and within statistical control, there needs to be a reconciliation. This may be accomplished by changing the standards to fit the existing capabilities of the system or changing the system so that the standards can be achieved.

Warehouse Refusal Rate and Location Accuracy Using the p-Chart. Two important measures of the quality of work in the supply center are the warehouse refusal rate and location accuracy. The warehouse refusal rate is the ratio of warehouse refusals to issues processed. Each day the warehouse receives a packet of issues to process. If the warehouse cannot find the material to satisfy an issue then that issue becomes a warehouse refusal. According to NAVSUP standards, a rate of 1 percent is satisfactory. A 1 to 2 percent warehouse refusal rate is marginal. A rate greater than 2 percent

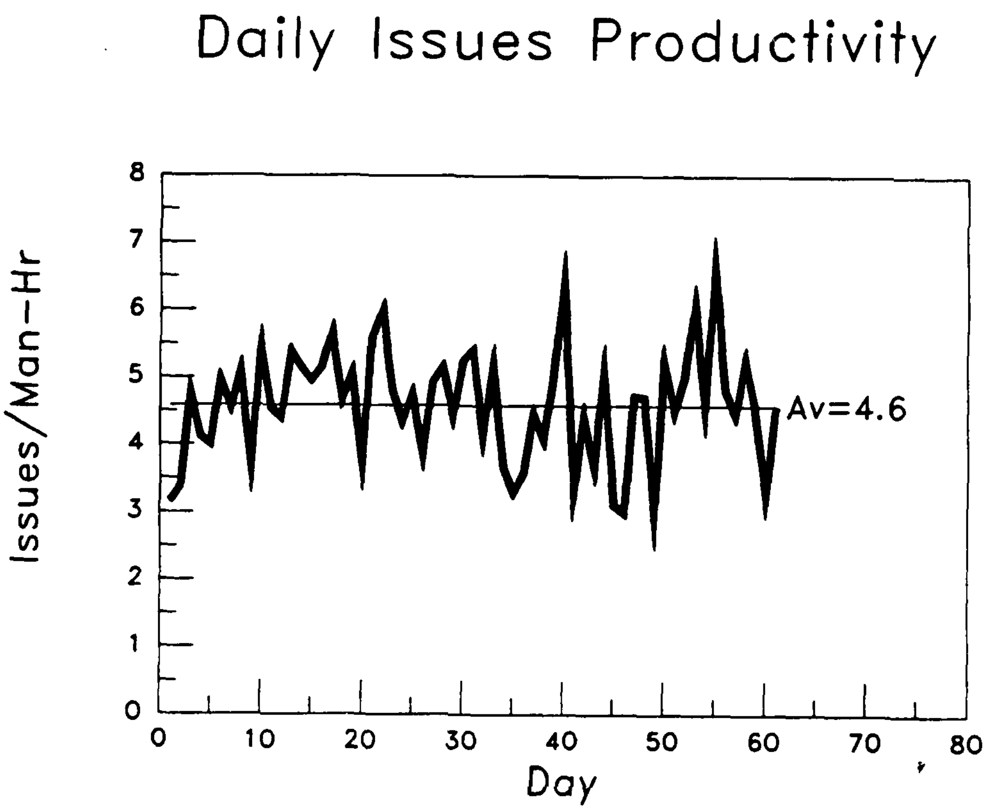

Figure 7. Run chart displaying number of issues processed per man-hour.

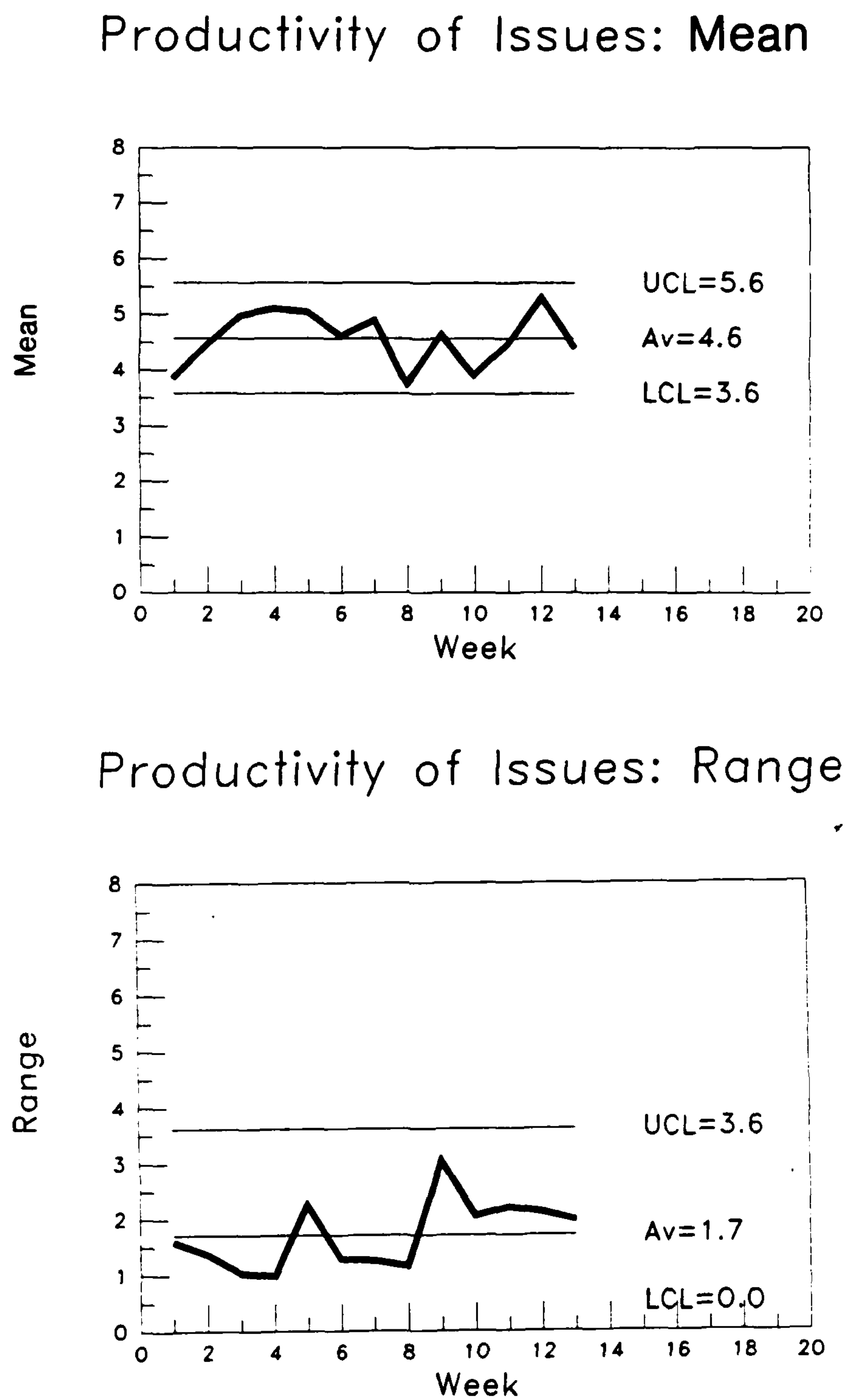

Figure 8. Mean and range control charts on productivity as it affects issues. Upper (UCL) and lower control limits (LCL) are indicated.

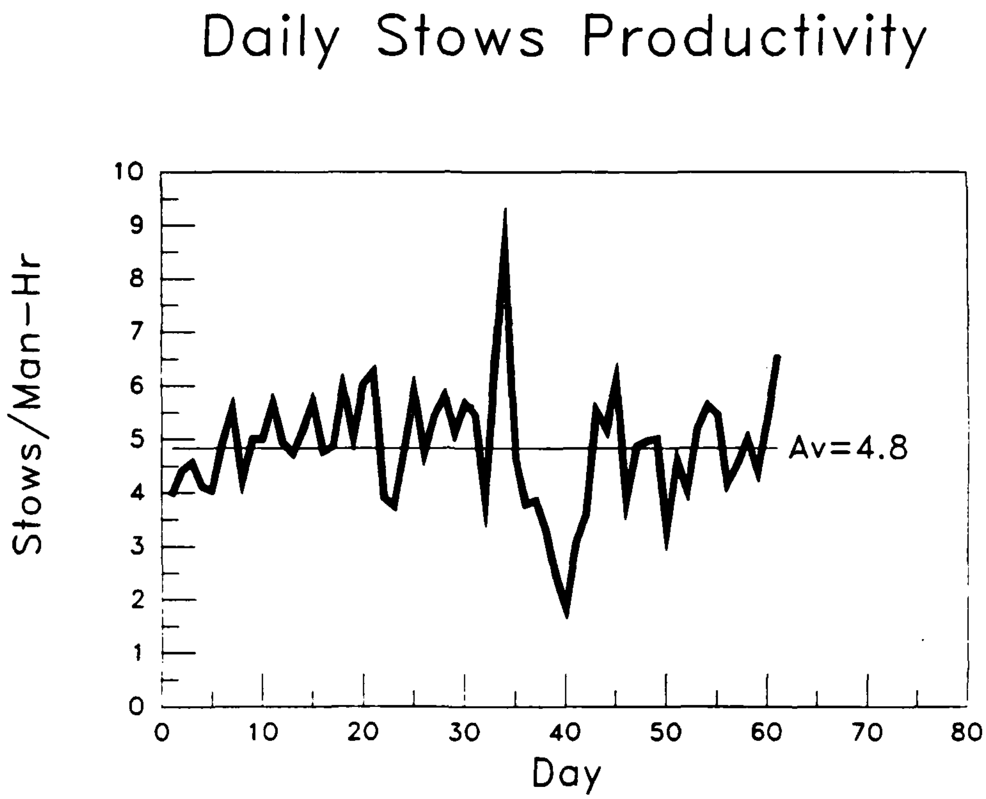

Figure 9. Run chart showing productivity data for stows.

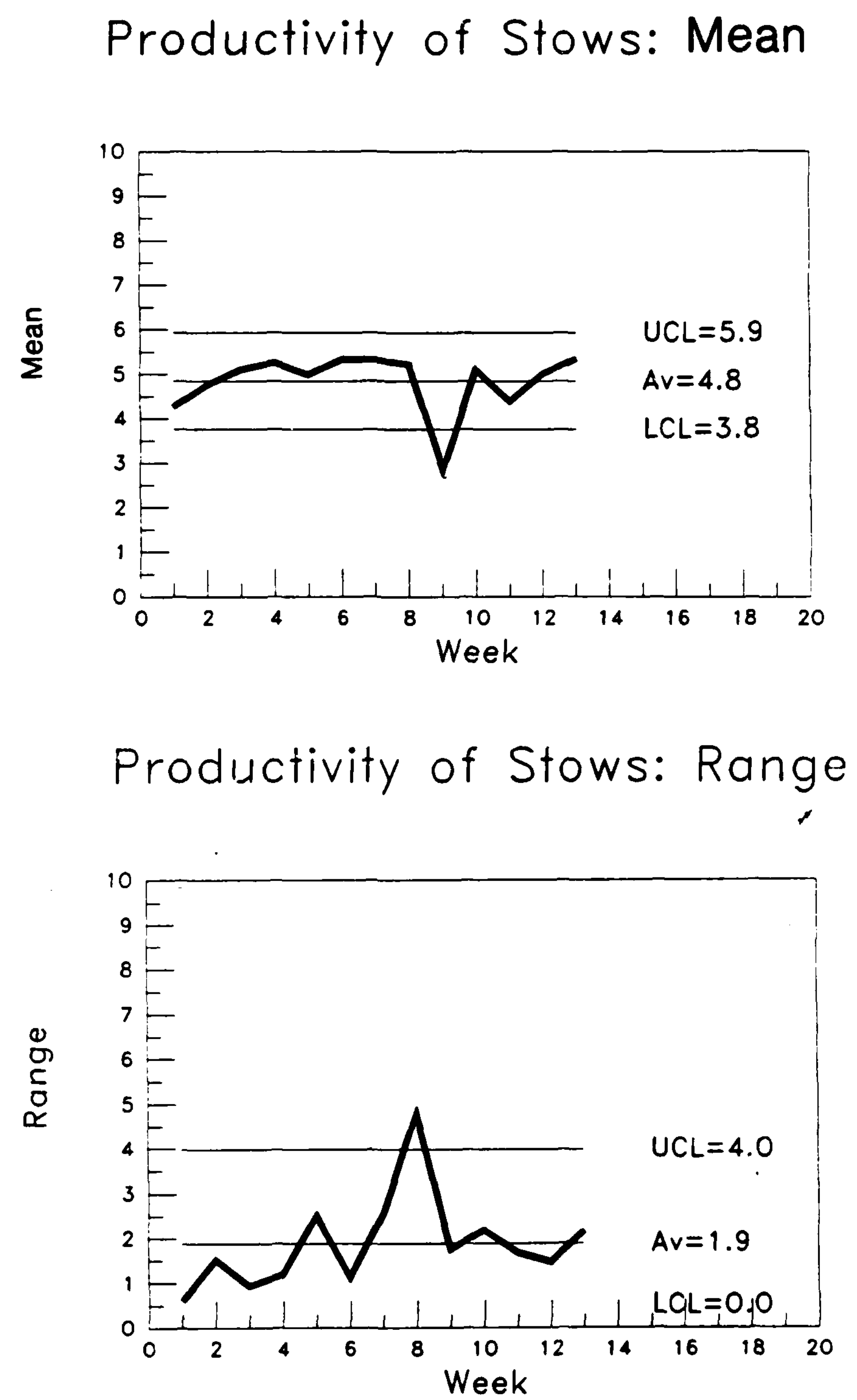

Figure 10. Mean and range control charts on productivity as it affects stows. Upper (UCL) and lower control limits (LCL) are indicated.

is not satisfactory. Location accuracy is determined by checking the items in a location against a report from the MSIR of the line items supposed to be there. A location accuracy of greater than 97 percent is satisfactory. (Private industry warehouses are satisfied with an accuracy rate of about 95%.)

The 544 building (not the entire work center) was certified to be 97.5 percent accurate, the result of a certification program established at the supply center. On the first examination the building was found to be below standard, but special "Tiger Teams" did a wall-to-wall reorganization that brought it up to par. The other buildings in the 544 work center will be certified later.

Figure 11 displays the warehouse refusal rate of the 544 work center (excluding the oil depot). It is in the form of p-chart which is similar to the mean and range control charts. However, a p-chart is used to monitor the fraction of output that is defective. In Figure 11, a warehouse refusal is considered a defective item; the output is the sum of successful issues and refusals. A p-chart does not include range or dispersion since that would have no meaning. The control limits for the p-chart are not fixed but change depending on the output; thus, they differ each week. As with the mean and range charts, managers will respond by taking action when the control limits are exceeded. The p-chart in Figure 11 is based on 13 weeks of data, which is not a large enough sample for a control chart. In this case, however, it serves to illustrate what is going on.

The average warehouse refusal rate was 2.5 percent, which is not satisfactory according to standard. The warehouse refusal rate is out of control with both high and low points.

When the chart was shown to managers, they hypothesized that the points out of control were a function of the warehouse holding the refusals. "Holding refusals" literally means to sit on the request for a few days in the hope that the material will be found. This tends to create a "bunching" of warehouse refusals on a particular day or week. Since the sample was drawn on a daily basis there are several very high points, some beyond the three standard error limits. The supply center is trying to stop the practice of holding refusals because it may increase the actual number of refusals. For example, another issue request for the same line item may arrive while the previous one is being held. If the first warehouse refusal had been processed when it occurred, the MSIR would have been changed to show that the item was not available at NSCO. Thus, the request for that item would be routed to another supply center instead of being refused.

How can the warehouse refusal rate be improved? The most practical way to do this is to require that refusals be turned in as quickly as they are recognized. This action brings the refusal rate under statistical control because there are fewer refusals.

How much change is possible? A simple statistical model shows that the warehouse refusal rate and the location accuracy rate are related. It helps to think of a set of issues as a "sample" from the warehouse. If it is a random sample from the entire warehouse, then the long-term successful issue rate should equal the location accuracy rate. If the location accuracy is 99 percent then the successful issue rate should not be higher than 99 percent. The warehouse refusal rate is 100 percent minus the successful issue rate (in the example, 1%), or 100 percent minus the location accuracy rate. A 97 percent location accuracy gives a 3 percent warehouse refusal rate. Interestingly, this means that the standards of location accuracy and warehouse refusal rate are linked. The Navy sets the standards independently, and they conflict.

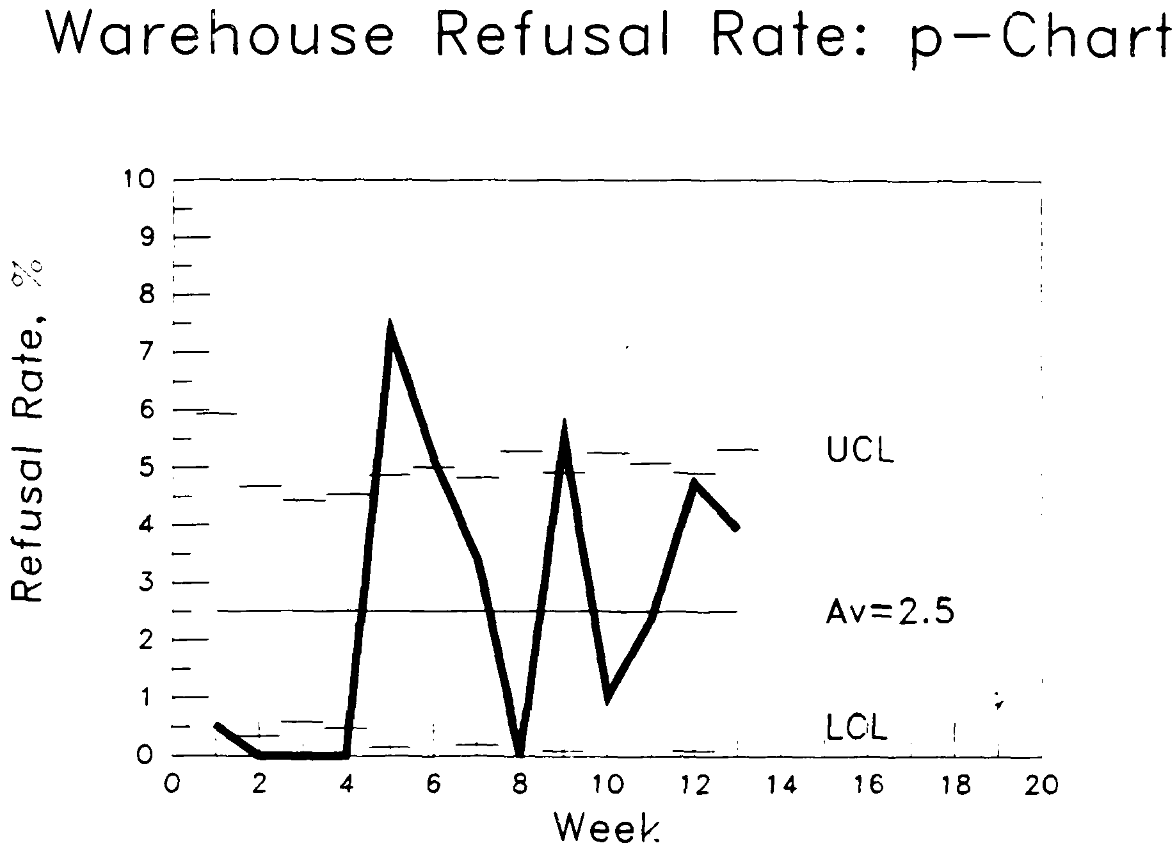

Figure 11. A p-chart showing warehouse refusals over a 13-week period. (Upper (UCL) and lower control limits (LCL) are indicated.)

In the case of the 544 work center, the location accuracy for the single building was 97.5 percent and the work center's overall warehouse refusal rate was 2.5 percent. We are measuring a slightly different thing here since the 2.5 percent is based on five buildings. Also, the set of issues may not be a true random sample; some items in the warehouse are there for long-term storage and would only be issued in the event of a war. But the statistical model does indicate that it may not be possible to significantly improve the warehouse refusal rate given the location accuracy rate.

CONCLUSIONS AND RECOMMENDATIONS

Sociotechnical analysis provided a conceptual and operational framework for understanding the processes and problems of the 544 work center. The identification of variances within and between the unit operations allowed the authors to design the necessary measurements for the important process control points (key variances). Collaborative efforts between 544 work center staff and NAVPERSRANDCEN resulted in a common understanding of what processes take place and where problems occur.

Many of the problems of quality control crossed boundaries to other organizations within NSCO. It became clear that an expanded technical analysis was needed to deal with some of the problems.

The variances determined by the technical analysis corresponded with the perceived problems of both managers and workers. They were already collecting much of the data necessary to monitor the variances; however, they did not know how to organize the data into useful information. SPC techniques (e.g., histograms, run charts, and control charts) provided a straightforward way to monitor the operation of the work center. Data necessary to monitor newly identified variances could have been easily gathered.

Statistical analysis also gave managers a tool by which to monitor the operation of the 544 work center and to understand the relationships of different parts of the system which were previously thought to be independent. In particular, they learned that statistics could be applied to the analysis of performance standards and NSCO's capability to meet those standards.

Since sociotechnical analysis and SPC methods can be applied to naval supply centers' operations, the following recommendations are in order.

1. SPC should be used to provide the naval supply center with quality control procedures needed to support NISTARS. Quality control problems that occur in the process can be measured. The supply center can use SPC techniques to monitor its own performance.

2. The Navy should investigate the feasibility of starting similar pilot programs at other Navy activities. Sociotechnical analysis and SPC are general, useful approaches to the analysis of an organization and the control of variation. Since the approaches were applicable at a supply center, they would likely work well at other industrial activities.

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APPENDIX A

UNIT OPERATIONS: STOWING, MAINTENANCE, ISSUING

UNIT OPERATIONS: STOWING, MAINTENANCE, ISSUING

Stowing

Figure 1 does not include the receiving operation for drums of petroleum products and other items stored outside. This function takes place within the 544 work center system itself (called direct receiving). Material from outside Naval Supply Center, Oakland (NSCO) becomes material which is now part of NSCO, both physically and as part of the record (master stock item record or MSIR).

The major routine processes in the stowing operations are:

1. Material with its material movement document (MMD) is placed at designated receiving areas in buildings 544 and 444 by the receiving contractor.

2. The warehouseman in the 544 work center checks the MMD against information on the container, on the material, on a tag, etc., for accurate stock number, condition code, quantity and other information.

3. If the information is consistent and there is no apparent reason to further inspect the material by opening the container, the warehouseman takes the material by hand or by forklift to the location listed on the MMD.

4. Material is placed in the location listed on the MMD.

5. The MMD is completed by marking the information that the warehouseman has checked against the information on the container; any necessary annotations are made and the MMD is taken to the foreman.

6. The MMD is sent to receipt control where the information is entered into the NSCO computer system. This completes a routine stow.

7. If the location(s) listed on the MMD are full or the material cannot be stowed at the listed locations, the warehouseman takes the material to an alternative location of his choice. The new location may already contain material with the same stock number as the material to be stowed. Consolidation then occurs. This is a major variation in the stow operation.

8. The new location is noted on the MMD by the warehouseman and taken with other MMDs to the foreman or leader.

9. The MMDs with location changes are entered into an IBM PC at storage control by a phone terminal in building 544.

10. The annotated MMD is transmitted to the storage control operation (not part of the 544 work center).

The outputs of the unit operations are represented as parallelograms in Figure 1. For the stowing operation, the routine output is material stowed in a location and ready for the next transformation (maintenance and/or issue) as well as a completed MMD which is sent to the receipt control operation (outside the 544 work center boundaries). Here the material (stock number, location, condition code, quantity and other information) becomes part of the central computer system record (MSIR).

It should be noted that inputs and outputs of the unit operations involve both the material and information about the material. There are many important variations other than consolidation of material. Some of these will be mentioned in Appendix B.

Maintenance

The most frequent maintenance activity involves updating the condition code for shelf-life items, chiefly drums of petroleum and petroleum products stored outdoors. Other maintenance activities include changing stock numbers on items, changing the unit of issue (rare) and conducting MSIR purges. The latter is a survey of locations for material which according to the MSIR has a zero balance. It should be noted that inventories are conducted routinely in the 544 work center but by organizations outside the boundaries of the work center.

Figure 2 represents a simplified flow diagram of three maintenance activities undertaken by the 544 work center staff:

1. Condition code changes (QSL listing).

2. Change notices for stock numbers (NSN).

3. Stock number changes stemming from discovered problems.

The left column (1) of Figure 2 represents the shelf-life items. The input to this process is a QSL listing originating outside the NSCO and transmitted by the requirements division of the supply center. The listing includes shelf-life items and their expiration dates. There is also an internal shelf-life file based on information received from outside NSCO and maintained in the 544 work center. This file is consulted on a monthly basis and leads to various condition code changes as items approach their shelf-life date. At times the work center will be instructed from outside to send a sample of a particular line item for testing. The results of the test are sent back to NSCO and any further changes in condition code as a result of testing are made in the work center. Changes in condition code are recorded on a change form and the completed change form is submitted to the storage control operation at NSCO. Condition code changes are made on the material by indicating the new code on the drum(s) at the beginning of the aisle in which the item is stored.

A second input (2) to the maintenance operation comes from change notices sent to NSCO regarding the change of an item's stock number. This is pictured as the second input in Figure 2. Here the change in stock number has already been registered in the MSIR. The activity in the 544 work center consists of changing the number on the material, usually on the container. No forms are completed since the stock number change is already on the MSIR.

A third source of input into the maintenance operation (3) is shown on the right part of Figure 2. This has been labeled "Discovered Problem with NSN." The discovery is often made by auditors making routine checks or searching for material that can not be found. Other sources outside the 544 work center may also discover a stock number problem. The "discovery" may also be made by 544 employees. Thus, the input is depicted both outside and inside the unit operation. Resolving the question concerning a stock number involves research using the MSIR, manual files of stock numbers and part numbers and other information sources. At times the information needed to obtain the correct stock number must be obtained by organizations outside the work center (within

NSCO, other federal agencies or vendors). Research on the item in question is shown as occurring both within and outside the unit operation. When the problem is resolved a change form is completed indicating the correct stock number. The completed change form is sent to storage control. The stock number is also changed on the material.

Other maintenance activities not shown include MSIR purges (described previously), changing locations of items in "F" condition (not ready for issue) from "A" condition (ready for issue) locations and vice versa. Occasionally requests come to the 544 work center which may involve an inventory of items, making location changes or making changes in unit of issue.

The outputs of the maintenance operation are the updated and correct condition code, stock numbers, locations, etc., indicated on change forms sent to storage control and on the material itself (markings, location). The change forms result in an updating of the MSIR.

Issuing

This unit operation concerns the movement of the material from storage and prepares it for the next operation (usually packing) before it is sent to the customer. On some occasions the material is given directly to the customer who picks up the material. No information is transmitted to receipt control or storage control by the work center in the issuing operation. Documents are sent with the material to the next unit operation (usually packing). Thus, the output is, in essence, the physical movement of the material out of the 544 work center.

Figure 3 represents the routine processes in the issuing operation. The steps are as follows:

1. Requisitions in the form of issue documents are delivered to the 544 work center. This is the input.

2. The issue documents are sorted by priority. Priority defines the time NSCO has to ship the material. There are three priority groups (I, II, III) indicated by the color of the issue document.

3. The warehouseman takes the issue document and locates the material based on the information on the issue document.

4. The warehouseman checks the material document at the location against the issue document in terms of stock number, condition code, unit of issue, quantity and other information to find a match.

5. If the material listed on the issue document is in the location indicated, the quantity of the material requested is picked out. This involves taking the material from the location in which it has been stowed.

6. The material is moved to a staging area.

7. The issue document is "recapped" and signed by the warehouseman. Recapping involves checking the document information against that on the material again--stock number, unit of issue, quantity, etc. The warehouseman makes a check mark on the issue document for each item of information that matches the document attached to the material.

8. All copies of the issue document are placed in an envelope. The envelope is marked with the location to which it will be sent next (usually a building number at NSCO), the priority of the issue, and the number of containers for that issue document. If there are several containers for an issue document, an envelope is sometimes placed on each container with a serial number and an indication of the number of containers, that is, 1 of 3, 2 of 3, 3 of 3. Envelopes are attached to the containers.

9. Transportation is called to take the issued material.

10. Material is loaded onto transportation (flatbeds, wagons, etc.).

11. The material is transported to the next unit operation from the 544 work center.

12. If the material on the issue document or the quantity of the material requested is not found in the location(s) listed on the issue document by the warehouseman (a condition not shown in Figure 3), then the following steps are taken.

a. The leader or foreman is notified and searches for the material.

b. A quality control inspector, if available, also searches for the material.

c. Any manual files containing recent changes in location are consulted.

d. If no material is found, the issue document is marked "NIS" (not in stock) and it is considered a warehouse refusal.

e. Inventory (outside the 544 work center) is notified and they take up the search.

f. If some material is found but not in the quantity requested, the issue document is changed with the quantity found marked and inventory notified of the shortage. The material continues to be processed as usual.

On some occasions the issued material will be given directly to the customer who comes to the 544 work center. Sometimes the material will be loaded onto transportation which will take it to the customer or to another mode of transportation (e.g., overseas shipment). The latter procedure occurs mainly for large items (propellers, anchors, shafts) and drums of petroleum products.

The output of the issuing operation consists of the material with attached documents loaded on transportation.

APPENDIX B

VARIANCES IN THE UNIT OPERATIONS
OF THE 544 WORK CENTER

VARIANCES IN THE UNIT OPERATIONS OF THE 544 WORK CENTER

A. STOWING:

VARIANCE	DEFINITION	DATA NEEDED	SOURCE
1. Equipment down-time (forklifts).	Number and amount of time forklifts not operating.	Number of assigned forklifts; number of work hours forklifts are down.	Public works Foreman
2. Volume fluctuations.	Variation in the number of line items (or number of containers, drums, etc.) arriving for stow per unit time.	Number of line items (or containers or drums) arriving plus number of line items backlogged.	Daily backlog and situation report
3. Worker training/motivation.	Degree to which the worker knows what he has to do and how to do it and is motivated to do his job correctly.	Tests, interviews, quality control record.	Warehouseman; quality control foreman and leader
4. Condition code questionable.	Condition code on container and/or MMD does not appear correct in terms of appearance of material or container or other information.	Number of line items for which there are questionable condition codes.	Leader or foreman
5. Mixed material in same container.	More than one line item is included in the same container.	Number of containers received with known mixed material.	Leader or foreman
6. Different parts of the same line item in different containers.	Different size and shape containers show the same NSN - must investigate to see if the parts are part of one NSN or if there is a wrong NSN on one or more containers.	Number of times material in containers of different sizes and shape with same NSN are brought to the attention of the leader or foreman.	Leader or foreman
7. Same line item in different size and types of containers.	Self-defined.	Number of same line items received in containers of varying size and shape.	Warehouseman
8. Material not packed or needs repacking.	Material judged to need preservation and sent to packing.	Number of line items needing preservation and sent to packing operation.	Manual file
9. Material does not match the NSN or MMD.	The material in the container does not appear to be the NSN indicated on the container or on the MMD.	Number of times warehouseman questions the accuracy of the NSN and brings to the attention of the leader or foreman.	Leader or foreman
10. Count accuracy.	Number of items in container not the same as number of items indicated on container or MMD.	Number of times warehouseman opens container to check count of items; number of times discrepancies discovered (quantity annotations on MMD).	Warehouseman or leader; MMD annotations

A. STOWING: (Continued)

VARIANCE	DEFINITION	DATA NEEDED	SOURCE
11. No specific location on MMD.	MMD shows building number and six zeroes; warehouseman selects location and puts actual location on MMD.	Number of MMDs with six zeroes; number of MMDs with annotations showing a location substituted for zeroes.	MMD
12. Location(s) full.	Location(s) listed on MMD are full.	Number of line items that cannot be stowed in specified locations due to full location(s); number of ZELs completed due to consolidation of material.	MMD annotations; storage control
13. Consolidation of material (location change).	Material moved from one location(s) to another location(s).	Number of ZELs; number of line items consolidated.	Storage control
14. Annotations on MMD.	Warehouseman makes annotations on MMD to indicate: location changes (consolidation); selection of a location when none was specified; quantity discrepancy between MMD and material; or change of NSN.	Number of MMDs with annotations; types of annotations.	MMDs and various computer files where changes are recorded
15. Location accuracy.	Is material stowed in correct location according to MMD?	Number of line items inaccurately stowed and total number of line items stowed per unit time.	Quality control; receipt control (for number of line items stowed)
16. "F" condition material from other buildings.	Unexpected "F" condition material arrives at the work center but not from the receiving functions.	Number of line items (or containers or pallets) arriving unexpectedly from non-receiving functions.	Warehouseman, leader or foreman
17. Returns from packing.	Material that has been issued from the work center and sent to packing is returned.	Number of containers, pallets or line items returned from packing.	Leader or foreman
18. Returns from repair facilities not repaired.	Material sent from a repair facility is returned unrepaired.	Number of line items returned from repair facility not repaired and requiring processing (perhaps stowing).	Leader or foreman
19. Number of stows made within time standards.	Number of stows made and MMDs completed and sent to receipt control within 7 days of arrival of material at receiving.	Number of line items stowed within time frames over total number of line items due for stow at that time.	Daily backlog and situation report; computer files

B. MAINTENANCE

VARIANCE	DEFINITION	DATA NEEDED	SOURCE
20. Volume of changes required.	The number of line items (or containers, locations) to be changed or checked--changes of condition code, items to be sent for testing, changes in NSN, number of cards to be inventoried in a MSIR purge.	Number of line items to be changed, tested or inventoried.	Daily backlog and situation report; requirements division; warehouseman
21. Consolidation of material (location changes).	Location changes that involve consolidation of material--moving material from several locations to fewer locations.	Number of ZELs made as a result of change notices involving location changes.	Daily backlog and situation report; storage control
22. Shelf-life updating (condition code changes).	Updating of condition code for petroleum products based on information from requirements at NSCO and from a monthly file indicating shelf-life expiration time.	Number of line items for which condition code changes are required.	Daily backlog and situation report; monthly requirements from file
23. "A" material in "F" areas or vice versa.	Material in "F" condition found in areas for "A" material and vice versa.	Number of line items changed from "A" to "F" or "F" to "A" areas.	Warehouseman or leader
24. Discovered need to change NSN or condition code.	Need for change in NSN, condition code or other aspect of material as a result of audits, formal inspection of informal discoveries.	Number of line items for which changes are made due to discovered discrepancies.	Foreman or leader
25. Changes needed when doing a MSIR purge.	Paperwork changes needed as a result of checking zero balance of material on the MSIR with material in location.	Number of discrepancies between MSIR and location with regard to presence of material; number of cards annotated.	MSIR; foreman
26. Fading of stenciled information on material stored outdoors.	Self-defined.	Number of drums or other material outdoors with illegible information.	Warehouseman
27. Number of changes made.	Total number of condition code, NSN and other informational changes made as well as location changes after material has been stowed.	Number of line items for which information and other changes are made; number of required changes (condition code, NSN, etc.) called for.	Daily backlog and situation report; MSIR; warehouseman

C. ISSUING

VARIANCE	DEFINITION	DATA NEEDED	SOURCE
28. Volume fluctuations.	Variations in the number of issues (including disposals) to be made.	Number of issue documents and backlog per unit time.	Daily backlog and situation report
29. Volume of priority I documents.	Number of priority group I issues to be made per unit time.	Number of priority group I documents arriving per unit time.	Daily backlog and situation report
30. Equipment down-time (forklift)	See variance #1.		
31. Worker training/motivation.	See variance #3.		
32. Condition code discrepancy.	The condition code on the issue document is different than the condition code on the container or than the obvious condition of the material.	Number of discrepancies per unit time.	Warehouseman or leader
33. Same line item in containers of different size and shape.	See variance #7.		
34. Different parts of same line item in different containers.	The line item is in more than one container, i.e., more than one container must be opened to obtain whatever is required for one of a given line item.	Number of line items to be issued in a quantity of one whose parts are in different containers.	Warehouseman
35. Material not found by warehouseman.	Material requested on issue document not in location(s) when warehouseman goes to find it.	Number of line items not found by warehouseman.	Leader
36. Material not found by others (warehouse refusals).	The leader, foreman and quality control inspector cannot find the material either.	Number of warehouse refusals (material not in stock).	Foreman; daily backlog and situation report
37. Quantity of material requested not found by warehouseman.	Material requested on issue document found by warehouseman but not in sufficient quantity to fill request.	Number of line items for which the amount of material requested was not found by the warehouseman.	Leader
38. Quantity of material requested not found by others (partial refusal).	Quantity of material requested not found by others (leader, foreman, quality control).	Number of line items issued with lesser quantity than requested.	Foreman; daily backlog and situation report
39. Material returned from packing.	See variance #17.		
40. Monitored items.	Issues that need to be sent immediately and monitored during each stage of the issuing process because they have high priority.	Number of line items monitored per unit time.	Leader or foreman
41. Customer direct pick-up.	The customer comes to the work center with the proper documents to pick up the material.	Number of line items picked up by customer per unit time.	Warehouseman or leader
42. Number of issues made within time standards.	The number of line items issued and sent to the next unit operation (usually packing) within the time allocated according to priority group.	Number of line items issued within time frames for each priority group over the number of line items to be issued (number of issue documents) per unit time.	Daily backlog and situation report; existing computer files

APPENDIX C

SAMPLE OF DAILY BACKLOG AND SITUATION REPORT

BACKLOG AND SITUATION REPORT
NSCO 5220/4 (Rev. 10-70)

☐ BIN ☑ BULK 401.113

UIT TO DISTRIBUTION			DAY OF WEEK	CALENDAR DATE	JULIAN DATE
				2-29-84	4060

BRANCH	BIN ISSUE IN	BIN ISSUE OUT	BIN ISSUE B/L	BIN ISSUE M/H	BULK ISSUE IN	BULK ISSUE OUT	BULK ISSUE B/L	BULK ISSUE M/H	REPLENISHMENT IN	REPLENISHMENT OUT	REPLENISHMENT B/L	REPLENISHMENT M/H	STOWS IN	STOWS OUT	STOWS B/L	STOWS M/H	DISPOSAL IN	DISPOSAL OUT	DISPOSAL B/L	DISPOSAL M/H	MAINT ACTIONS IN	MAINT ACTIONS OUT	MAINT ACTIONS B/L	MAINT ACTIONS M/H	RECEIPTS IN	RECEIPTS OUT	RECEIPTS B/L	RECEIPTS M/H
W/C																												
OLDEST DATE																												
W/C																												
OLDEST DATE																												
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OLDEST DATE																												
W/C																												
OLDEST DATE																												
SUB TOTAL																												
W/C																												
OLDEST DATE																												
W/C																												
OLDEST DATE																												
W/C																												
OLDEST DATE																												
W/C																												
OLDEST DATE																												
W/C 544	11	11	Ø	3	97	97	Ø	15					61	67	56	36	Ø	Ø	65	Ø	39	39	Ø	4				
OLDEST DATE													4467															
W/C 444					5	5	Ø	1					10	Ø	10	Ø												
OLDEST DATE													4462															
W/C 643					1	1	Ø	1																				
OLDEST DATE																												
SUB TOTAL	11	11	Ø	3	103	103	Ø	17					71	67	66	36	Ø	Ø	65	Ø	39	39	Ø	4				
GRAND TOTAL	POTENTIAL NIS' - Ø																				DRUM STOW B/L = 720							

TOTAL ASSIGNED HOURS	72	WHSE REFUSALS		FORKLIFTS AVAIL	7
BORROWED	8	544	7	ASSIGNED	8
LOANED OUT	—	543	1		
SCHEDULED LV	—	542	1	NIS 4	DOCS DIED
SICK LV	—	—	—	RED 2	RED Ø
ADMIN LV	—	—	—	YELLOW 2	YELLOW Ø
AWOL	—	—	—	WHITE 3	WHITE Ø
LWOP	—	—	—		

FLIPS Ø

ITEMS RED LA	ITEMS YEL LA	WH REFUSAL PAR	WH REFUSAL COMPL	BEAR PICK-UP LA	BEAR PICK-UP M/T	RAILCARS NO	RAILCARS M/T	RAILCARS M/H	TRUCKS NO	TRUCKS M/T	TRUCKS M/H
48	44	1R 1W	3R 2Y 2W	1	1	Ø	Ø	Ø	1	58	4

PREPARED BY

M/H SUMMARY (Optional) TYPE	EXPEN.
DIRECT	64
INDIRECT	16
SUPPORT	
LEAVE AA	
SA	
TOTAL	80

Replaces 12ND NSC 5220.33, 5220/92 and previous issues of this form which are obsolete

APPENDIX D

SPECIAL DAILY REPORT FOR 544 WORK CENTER

SPECIAL DAILY REPORT

544 Work Center

DATE ____________________

STOW

1. Number of Line Items with Questions about Condition Code During Stow

   1 2 3 4 5 6 7 8 9 10 11 12 13 14
   15 16 17 18 19 20 21 22 23 24 25 26
   27 28 29 30 31 32 33 34 35 36 37 38

2. Number of Containers with Mixed Material (more than one line item) Discovered During Stow

   1 2 3 4 5 6 7 8 9 10 11 12 13 14
   15 16 17 18 19 20 21 22 23 24 25 26
   27 28 29 30 31 32 33 34 35 36 37 38

3. Number of Line Items with Questions About NSN During Stow

   1 2 3 4 5 6 7 8 9 10 11 12 13 14
   15 16 17 18 19 20 21 22 23 24 25 26
   27 28 29 30 31 32 33 34 35 36 37 38

4. Number of Line Items with a Quantity Discrepancy (count vs. MMD or what is listed on container)

   1 2 3 4 5 6 7 8 9 10 11 12 13 14
   15 16 17 18 19 20 21 22 23 24 25 26
   27 28 29 30 31 32 33 34 35 36 37 38

5. Number of MMDs with Location Changes (Deletions, Additions or Consolidations) ____________________

6. Number of MMDs with Locations Established (000000 on MMD) ____________________

7. Number of ZUDs Received ____________________

RETURNS

8. Number of Separate Containers Returned From Packing After Being Issued ____________________

9. Number of Line Items, Not Repaired, Returned From Repair Facilities

   1 2 3 4 5 6 7 8 9 10 11 12 13 14
   15 16 17 18 19 20 21 22 23 24 25 26
   27 28 29 30 31 32 33 34 35 36 37 38

MAINTENANCE

10. Number of Line Items With "Discovered" Need for Change of NSN, Condition Code, etc., already in stow and taken out of stow. DO NOT INCLUDE ROUTINE CHANGES SUCH AS QSL OR ZSW

    1 2 3 4 5 6 7 8 9 10 11 12 13 14
    15 16 17 18 19 20 21 22 23 24 25 26
    27 28 29 30 31 32 33 34 35 36 37 38

11. Number of ZSWs Worked ____________________

12. Number of MSIR Purge Cards Worked ____________________

13. Number of MSIR Purge Cards Annotated (More than 0 balance) ____________________

ISSUE

14. Number of Line Items with Condition Code Discrepancy At Issue

    1 2 3 4 5 6 7 8 9 10 11 12 13 14
    15 16 17 18 19 20 21 22 23 24 25 26
    27 28 29 30 31 32 33 34 35 36 37 38

15. Number of Line Items Not Found by Warehouseman At Time of Issue

    1 2 3 4 5 6 7 8 9 10 11 12 13 14
    15 16 17 18 19 20 21 22 23 24 25 26
    27 28 29 30 31 32 33 34 35 36 37 38

16. Number of Line Items For Which Warehouseman Cannot Find The Correct Quantity At Time of Issue

    1 2 3 4 5 6 7 8 9 10 11 12 13 14
    15 16 17 18 19 20 21 22 23 24 25 26
    27 28 29 30 31 32 33 34 35 36 37 38

____

Signature

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